Networks, Technology, Security, and Applications in the Health sector for IOT enabled Smart Wearable: A Review

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| Varalakshmi B D  Department of Computer Science and Engineering  Acharya Institute of Technology,  Bangalore, India  [varalakshmi@acharya.ac.in](mailto:varalakshmi@acharya.ac.in) | Mallamma C G  Department of Computer Science and Engineering  Sambhram Institute of Technology  Bangalore, India  [mallammagoudar79@gmail.com](mailto:mallammagoudar79@gmail.com) |
| Nagapushpa K P  Department of Electronics and Communication Engineering  Acharya Institute of Technology, Bangalore, India  nagapushpa@acharya.ac.in | Aruna M  Department of Electrical and Electronics Engineering  Nitte Meenakshi Institute of Technology, Bangalore, India  aruna@nitte.ac.in |

ABSTRACT

With the advent of technology there is a lot of research work happening in the domain of Internet of Things(IoT) as it directly influences the common persons day to day life. This research work brings out several related works together with the relevance on technology, security, networking in IoT and its applications. The recent advancements which are influencing the wearable’s and the way they are dealt with modern technology is also reviewed here. The technologies which are existing will have to deal with multiple issues when collecting data, processing, analyzing and contemplating the data are also summed here.

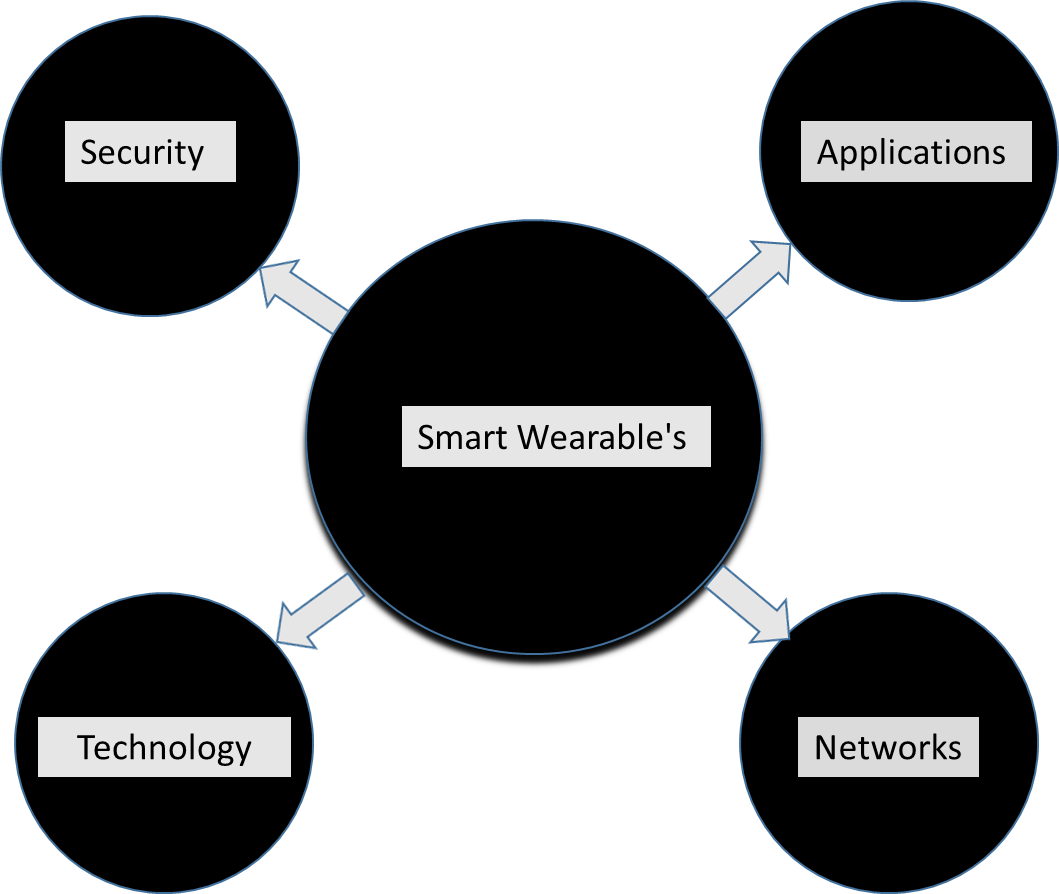
**Keywords : Wearables, IoT, Security, Healthcare, Artificial Intelligence**

I .INTRODUCTION

An intelligent wearable collects data from the user and analyzes it, and in some cases, it can make intelligent judgments and respond to the wearer in a timely manner. Internet of Things based wearable devices are classified into four key groups in this paper: (i) Networks (ii) Technology (iii) Security (iv) Applications. Data are gathered for these topics within each cluster, and they are reviewed and analyzed in detail.

The paper is organized as below, in Section II provides an overview of the Networks in wearable supported by IOT. Sections III Wearable device technology, Section IV discusses Security in IoT wearables for healthcare, Section V focuses on applications of IoT related variables. Finally, the conclusion explains how when all these four aspects are put together the wearables in IOT become more effective and improves the quality of life of the people who are using it and also the people who are moderating it.

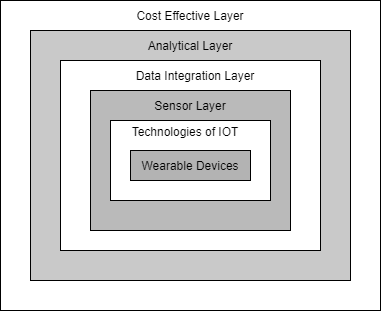
Despite the fact that mobile IoT offers numerous benefits and can significantly improve the functionality of IoT wearables, it has not been used effectively so far, according to the analysis that was conducted. [1] A comprehensive analysis of the chosen topic was performed by examining a variety of sources including IEEE Xplore and the digital library of the Association for Computing Machinery (ACM). There is a need for constructing a classification system for smart wearables, networks, and applications encompassing the Internet of Things as depicted in Figure 1.



**Figure 1. Different clusters in IOT and its applications.**

II. NETWORKS

The study conducted by [9] presents a Health Monitoring Observer Network for monitoring the health of a patient via IoT and wearable devices. The architecture is motivated by the Forest Fire Observer Network and is made up of three layers. As the first layer, the sensor layer measures vital signs from the patient, and it is connected to the network modules so that it can share the information of the patient with the underlying network. Data from sensors is grouped into a common group by the second layer, which combines values and data from sensors. [9] The next layer is the analytical layer, which holds software and techniques for problem detection. Furthermore, in addition to these layers, the study recommends a supplementary layer that extends across all the layers of the architecture in a cost-effective manner. [9]



**Figure 2: Organization of Wearable devices network**

An interesting wearable hydrogel sensors provide an appropriate option for wearable electronics and match well with the present manufacturing approach for connecting and correlating with a huge number of Internet of Things devices. This is due to their parts and structures, which are similar to human skin with the characteristics similar in their flexibility, ability to scale up, biocompatibility, and self-healing capabilities. Wearable hydrogel sensors are categorized to enable for a complete investigation of their configuration, mechanism, and design methodology. The article emphasizes current research on the primary structural components of wearable hydrogels: strengthening networks and conductive systems, giving prominence on various ways for increasing mechanical and electrical properties. The research gives an exhaustive analysis of wearable hydrogels and contains advice for the scheme of components and structures required to produce hydrogel sensors which are wearable and gives excellent performance. [15]

This paper suggests a distributed energy efficient clustering and routing technique for WBANs which are enabled by WioT. The distributed energy efficient clustering is divided into three phases: cluster development, Custer Head collecting, and direction-finding. Cluster construction makes use of two hop neighbor statistics. The statistics related to two hop neighbor broadens the local picture of network topology, and aids in network topology maintenance. An analytical prototype is proposed which aids in computing the appropriate figure of collections in the setup. This routing uses low energy boosts communication within and outside the clusters. Their proposed distributed energy efficient clustering and routing protocol beats others in terms of better delay, factors influencing the control, time required for cluster formation, cluster durability, and network energy usage, according to simulated results. Besides, distributed energy balancing among nodes significantly increases the overall lifetime of the network.[16]

**III. TECHNOLOGY**

Wi-Fi and Bluetooth Recent events have seen hackers capture control of cars, trains, even dams. IoT devices are particularly vulnerable to hacking and covert hiring attempts to assault the online world. It poses a serious risk to internet security. For ethical hackers looking for security flaws, IoT and embedded devices present a new challenge. Globally, the media and governments are becoming increasingly concerned about their own security problems. 5G networks will be critical in smart healthcare wearable devices. Considering healthcare and wearables within the 5G network, 5G technology is critical from both a functional and financial standpoint. A few 5G applications in wearables and healthcare are mentioned in the research work.

An in-depth analysis of various technological breakthroughs for achieving these standards in a 5G network was also conducted. Academics now have more opportunities to conduct research projects in the field of 5G-based health-related gadgets, and making wearables smaller and lighter is a big benefit. A slim, attractive band is more likely to be worn than a huge, cumbersome watch. Smart rings and "wearables," such as smart earphones, become increasingly appealing as they become smaller and lighter. Healthcare practitioners could use analytics to examine data sent over 5G from a wearable device for patients with chronic health conditions. The patient would get feedback right away on whether everything was alright, whether to make an appointment, or, in the worst case scenario, whether to get emergency treatment. As a result, it has been noticed that the network vanishes whenever big groups of people try to use it. The wearable technology sector would benefit from 5G's ability to handle these issues. Earlier studies concentrated on using AI solely for resource efficiency, such as reducing delays and increasing reliability, or improving overall security. The issue of identification for IoT 5G wearable medical equipment has not been solved. [17]

Rectenna wearable energy harvester (RWEH) for power generation is a relatively new area of study. However, further study is required to improve the harvester's power producing potential. PWEH research has expanded due to promising results in wearable applications, as it has the ability to produce power in the mW range, which would be sufficient to power wearable systems and be recognized as suitable for fabric applications. Surprisingly, despite the positive results, not enough research is being undertaken in the S.E.Hs and EWEHs for wearable applications. The HWEHs, particularly the RWEHs, will become a significant research area in the coming decades and may perhaps extend further. In the future, it is expected that W.E.H.s will be used to fully power and operate a variety of wearable gadgets and devices, such as in sports and fitness, where they can be used for a fitness tracker, pedometer, heart rate, breathing rate, movement pattern, and electrical muscle activity; for entertainment in smart watches and ear buds; in education for smart eyewear; in the military for eyewear, smart textiles, smart key chains; and in health care.

As a result, in the future, there will be a need to investigate materials and structural designs in order to maximize the system's stability under prolonged use while maintaining the device's wearability. Future systems are most likely to use H.E.H. technology, which integrates many transduction approaches; however, because of large differences in the amplitude, waveform, and frequency of electrical energy generated by various transduction processes, developing power management systems suitable for multiple energy harvesting techniques remains a challenge. Furthermore, self-powered gadgets are being integrated with an increasing variety of functional modules. Design circuits should be logically built to maximize the effectiveness of energy conversion and achieve power distribution across many functional units. Surface micro and nanostructures are one technique to increase the surface area of contact and improve energy harvesting efficiency. However, there are other options, such as using composite materials, external circuit systems, or even designing a mechanical structure. Researchers in wearable technologies are researching W.E.H.s to address the issue that batteries cannot supply the power requirements of wearing devices. The literature on PWEHs stresses their size, power, and flexibility. Furthermore, E.E.H. has a strong electromechanical coupling and operates well at low frequencies, making it suitable for wearable technologies. WTEHs, on the other hand, do not require an additional power source, are lightweight, and are less expensive. They have high availability and reliability. S.E.H.s have high power density but are greatly dependable on the light. Although HWEHs require a sophisticated circuit design, it delivers adequate power to the wearable device. In conclusion, it can be claimed that wearable technology has advanced significantly and may dominate future generations of electronic gadgets and devices. Wearable devices will become more widely used due to rapid advancements in materials science, smart technology, and process technology. [18]

Wearable Internet of Things (IoT) devices have become more and more commonplace in various healthcare services throughout time. One of the amenities that result from the use of wearable technology in eHealth is early diagnosis, which enhances predictive analysis. But because wearable IoT devices have constraints, issues with data privacy, service integrity, and network structure flexibility have emerged. A platform employing federated learning and private blockchain technology inside of a fog IoT network is suggested as a solution to these issues. These technologies secure data within the network with privacy-preserving features. An adaptive network for wearable IoT devices was built using the distributive structure of a fog IoT network. The capacity of the suggested platform to maintain the integrity of a classifier was tested using a testbed. According to testing results, the proposed implementation can successfully protect a patient's privacy as well as the integrity of a predictive service. Additional research was carried out to learn more about the contributions of various technologies to the security and adaptability of the IoT network. Overall, analysis, modeling, and experimentation were used to demonstrate the platform's practicality in solving important security and privacy challenges of wearable IoT devices in predictive healthcare. [19]

Wearable technologies have their own advantages and disadvantages depending on their usage, power consumption, range, latency and transmission rates. The same has been brought out in the below mentioned table.[20][21]

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| **Technologies** | **Advantages** | **Disadvantage** |
| Low-Energy Bluetooth | Low Power, Long Use | Small data range |
| Low-Energy Wireless | Low power consumption, device safety | Cannot be used over long distances |
| ZigBee, Z-Wave, and Thread | low-power, high throughput | Transmission rate is low |
| LTE-A | Reduces Latency, Increases throughput | Open to Interference |
| Wi-Fi-Direct | Connects without access points, low latency | Inefficient for large networks |
| LPWAN (Cat-M1/NB-IoT) | Provide long-range communication, uses small low cost batteries. | Can only send small blocks of data at a low rate. |

**Table 1: Technologies used in IOT**

**IV. SECURITY**

The research conducted in [3] focuses on the primary security concerns of IoT systems in order to educate consumers about the risks associated with these devices. IoT threats have been divided into several categories to aid comprehension. In addition, each class is thoroughly compared. Network attacks are initiated by injecting malicious nodes in order to steal information packets and degrade network performance. Side channel attacks are used by attackers to simultaneously target security and privacy. During strategy level attacks, attackers employ a variety of approaches to introduce harmful malware into IoT devices. Physical and logical attacks are differentiated by whether they can be carried out physically or remotely. Physical attacks wreak havoc on hardware components and necessitate physical contact. Remote logical attacks are possible. Because an attacker might be either an outsider with no prior knowledge of the targeted IoT system or an insider who is familiar with it, IoT attacks are categorized as internal or external based on antagonist location.

In hardware compromised assaults, the attacker tampers with the hardware in order to steal data. The deliberate insertion of malicious programs into a device in order to gain unauthorized access to it is referred to as a software attack. Due to faulty code, hackers get access to these IoT web applications, databases, or servers. Firmware attacks are carried out as a result of a failure to update firmware. [3]In order to aid manufacturers in safeguarding IoT systems, the complete literature study separated these categories into subcategories and evaluated over 75 IoT security concerns. In today's environment, new developing technologies such as block chain, artificial intelligence, machine learning, and other advanced technologies (fog and cloud computing) are being fused with IoT technology to address security and privacy problems. These emerging technologies, particularly block chain technology, have the potential to give a better and more cost effective solution to IoT security challenges. In the end, the review paper is summed up by suggesting some future research ideas in IoT security, which still need researchers’ attention. [3]

The study's major purpose was to research the aspects that contribute to trust and, ultimately, the intention to use WIoMT devices, as well as the impact of those independent variables on the outcome variable and the security issues associated with WIoMT adoption. The TAM model was used to extract the study's independent variables/domains, which were perceived usability, perceived ease of use, reliability, functionality, and perceived security and privacy.[5]

The study adds to the literature on the adoption of WIoMT devices in our daily lives through investigating how usability, ease of use, security, and privacy affect consumer trust, which eventually leads to the behavioral purpose to use such devices on a regular basis. Furthermore, the study found that security and privacy considerations have the largest influence on the use of the WIoMT, and manufacturers, healthcare providers, and vendors must focus on what consumers believe if they want to promote the global acceptance of their technology.

According to the report, many potential users are unfamiliar with or do not use WIoMT devices. The usage of equivalent or updated WIoMT technology should be made more acceptable and widespread in future research. Researchers should look into more people who are utilizing WIoMT devices in bigger geographical areas to learn more about their attitudes toward adoption. [5]

The Internet of Things has opened up a world of infinite opportunities for applications in various sectors of society, but it also presents numerous obstacles. One of these difficulties is security and privacy. IoT devices are more vulnerable to security threats and attacks due to their limitations. A lack of adequate security solutions for IoT applications is causing this universe of securely connected things to devolve into an internet of insecure things. The current state of security in IoT and what clarifications must be implemented to convince users that IoT is more than just providing low-cost gadgets have been discussed in the review done by [6], but equally important is providing the best security solutions that address security threats and privacy concerns. Users, security administrators, and upcoming IoT developers must all be aware of IoT security in order to maintain it. The role of the developer is to ensure that security is the main goal when designing and developing a device or program.[6]

The essay explores IoT security vulnerabilities from many perspectives (hardware, software, and data in transit), stressing precautions related to various security concerns. A discussion of existing security solutions is also provided. A thorough examination has been done to resolve the limitations that IoT devices face. A comparative review of all known hardware security solutions was undertaken with the purpose of providing security to IoT limited devices. The introduction of new technologies into the IoT ecosystem creates new vulnerabilities to overall network security. The study presented here focuses on the influence of two key developing technologies, machine learning techniques and block chain technology, on security when used in an IoT platform. It also proposed strategies to mitigate the risks that had been demonstrated. This could assist researchers with fresh directions to contribute to the field. [6]

To improve the performance of health data retrieval, the proposed method makes use of NDN benefits such as PIT aggregation, in network caching, and name based searching. IoT devices are the primary driving force behind the sensing and recording of patient health data. Furthermore, each wearable device serves as the leader in gathering and transmitting data to edge devices. Failure of any in charge would disrupt the entire monitoring for that specific patient, putting his life in danger in the event of an emergency. In the upcoming work, the research will move towards designing an optimal framework where periodic assignments will be considered for choosing and in charge from a single wearable device. This scheme will be tested in a more realistic setting, such as a multiage scenario, and examine the potential of defining separate edge servers with varying trust levels and dispersing all fragments across edges via Encryption. [8]

The increase in popularity of wearable devices and the continuous adoption by a large portion of the population of this technology to track their daily routines require that the manufacturers of these devices can ensure the confidentiality, integrity, and availability of the data that is being gathered. Some of the most recent smartwatches collect sensitive data, such as health in‐ formation, in an accurate manner that allows users to gain trust in these devices and know when to reach for a medical consultation. The method used here is passive to attack the devices; it helps to understand which devices would be the best targets to exploit their weak pairing protocols and start to read real time information about the users. As these technologies keep growing and adding sensors, the attacker would be able to obtain sensitive real time data and create a profile of a possible victim. [10]

The significance of an IoT legislative framework that requires suppliers to adhere to security and privacy criteria in order to develop a new IoT product is emphasized. A law requiring IoT security and privacy regulations assures that all devices follow a set of minimal security and privacy requirements. Although it is outside the purview of our study, the work assumes that it is important to create the justifications for additional work in this area, such as (i) protecting consumer privacy; (ii) preventing cyberattacks; (iii) promoting industry standards; (iv) encouraging innovation; and (v) establishing trust. Customers are more inclined to purchase and utilize an IoT gadget if they are certain that their personal information is being managed securely and responsibly. It is well recognized that consumers share some of the responsibility for information; smartwatch users must be mindful of the dangers of exchanging private or sensitive information with another device. In this situation, the fact that a smartwatch can employ the Just Works association models is probably due to the fact that the data is not encrypted. However, it is understandable that there is a lot of misunderstanding about how pairing authentication and data exchange work between a smartphone and a smartwatch, and at the end of the day, it is difficult for a non-knowledgeable user to understand this process, so vendors must also do their job by ensuring that devices will comply with the confidentiality and integrity of the user's information. [10]

**V. APPLICATIONS**

Smart Wearables can be classified as 1) Wearable 2) Implantable and 3)Stationary. Wearable devices have the potential to change many aspects of human existence, particularly healthcare, activity monitoring, and computer interaction. However, a variety of technological and adaption obstacles impede the wide availability and regular use of wearable devices.

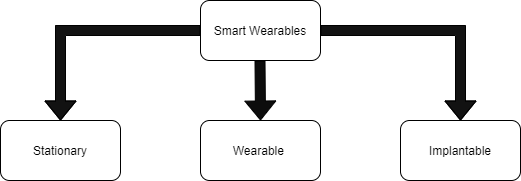


Figure 3: Classification of wearable devices

Through recent research efforts that have been concentrated on recognizing these issues and finding answers, wearable technology's potential can now be realized. The paper starts out by reviewing recent research on the challenges faced by wearable technology. The various solutions to each issue are discussed after that. The main applications that benefit wearable gadget users come first in our discussion. The design of physically flexible and bending devices that aim to increase user comfort is then presented. Modern energy harvesting and security techniques are also covered in order to increase wearable device user compliance. Overall, the goal of the article is to provide as a thorough resource for issues with and recommendations for self powered wearables for activity and health monitoring. [2] as illustrated in the below Figure 4.[5]

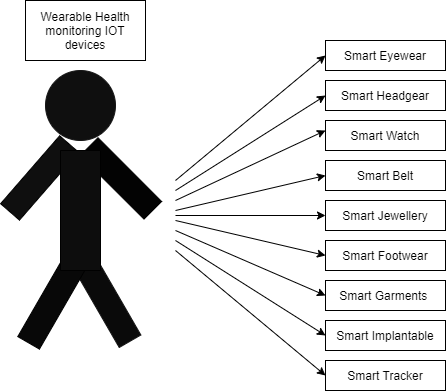


Figure 4: Different types of body wearables

The COVID-19 pandemic has, in summary, brought attention to the critical need for additional cutting-edge instruments and technology to control epidemics in the future. The study suggests a wearable, Internet of Things (IoT)-based health monitoring system that can remotely track the physiological characteristics of individuals under quarantine in real time. The method can greatly lighten the load on medical staff and aid in more efficient COVID-19 pandemic management. Additionally, it can be applied as a preventative strategy to stop the spread of upcoming pandemics. To solve the gaps in the currently available instruments for preventing epidemics, a one-to-many system made up of an anti-epidemic watch and a tiny computer has been developed.

It can passively stop those in quarantine from leaving, block the virus's tracks, and stop the infection from spreading, safeguarding the public's health. A healthcare professional and the owner of the anti-epidemic watch can both view the status of the system, which continuously monitors the body temperature, heart rate, and blood oxygen concentration. Demands for quarantine have significantly decreased as the world gradually lowers the blockade. To address acknowledged issues and challenges, the one-to-many monitor system project will still continue to be developed and enhanced. For instance, the anti-epidemic watch's battery capacity, the PPG module, and the IoT design, which are aspects of the next-generation design, must be taken into account.

In order to meet more flexible server programming requirements, it is important to request a dedicated server or virtual environment. The second generation anti epidemic watch is being developed with an emphasis on hardware and software design, despite the limited funding and human resources available. The cloud-based IoT functionalities are also progressively growing. In the future, a system will be created to transfer data to various kinds of smartwatches and display information directly on the watch. Furthermore, abnormal condition warning features will be improved, such as better monitoring of physiological indices, printing reports, historical data inquiries, and data analysis. The current project's major goal is to develop a system that will eventually become a mature product capable of efficiently controlling not only COVID-19 but also future pandemics.[7]

According to [12] research conclusions such as 1) wearable devices are increasing yearly, and wearable devices have attracted much attention. 2) The evaluation factors of IoT wearable devices can be divided into factors for model evaluation and sub components for device evaluation. 3) Describes communication technologies used in IoT wearables, concluding with, a discussion is conducted on the open issues and challenges of wearable devices. This research work has only limited research papers and provides a reference for evaluation factors and field selection for research in wearable IoT. [12]

Because of wearable technology, the well-known category of gadgets now comprises entirely new and rapidly evolving technologies. Wearable technology has the potential to supply a lot of important data to artificial intelligence (AI) approaches, in addition to being appealing and furnished with cutting-edge hardware technologies like as communication modules and networking in the next generation. Several projects have previously been accomplished utilizing a variety of AI methodologies, including monitored, unattended, semi-supervised, and reinforcement learning (RL). The article looks at current wearable apps that have employed AI to achieve their goals. Users discuss particular examples of both supervised and unsupervised usage in medical diagnosis. In addition, cases combining augmented reality, wearables, and the internet of things are discussed. Wearables application samples for specific industries, such as healthcare, commercial, and athletic, are also offered. Personal exercise, mobility issues, and mental wellness are all implications in medicine. Employee productivity can be increased by the usage of wearable technology at work. The fundamental objective of sports programs is to increase client happiness by encouraging physical activity or competition. The major problems with designing and building wearable technology are explored, as well as the computational expense of using Artificial intelligence methods. The potential and challenges for wearable technology in the future are examined.[14]

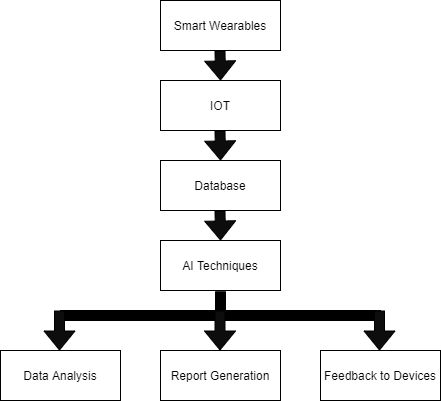


Figure 5: Wearable’s with AI Techniques

**CONCLUSION**

Among the main domains the authors have focused on the recent works on wearable’s using IOT. The work covers the major field of networks, technology, security issues in wearable’s using IOT. The future studies can be done in detail in each of the mentioned domain and also will get to know the recent advancements in the related fields.

Declaration of conflicts of Interest: All the authors declare no conflict of interest.

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